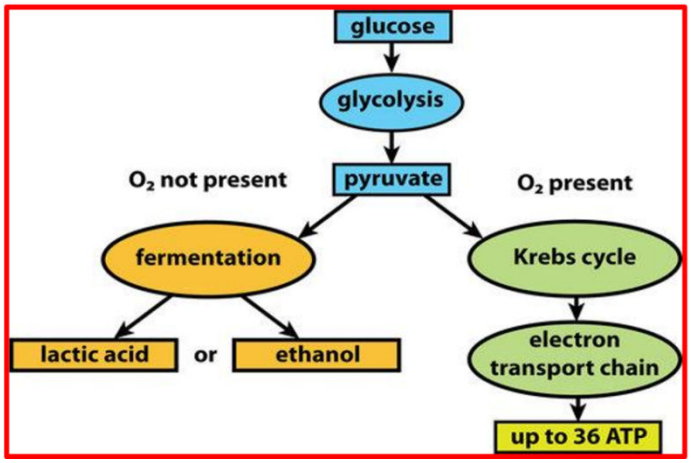
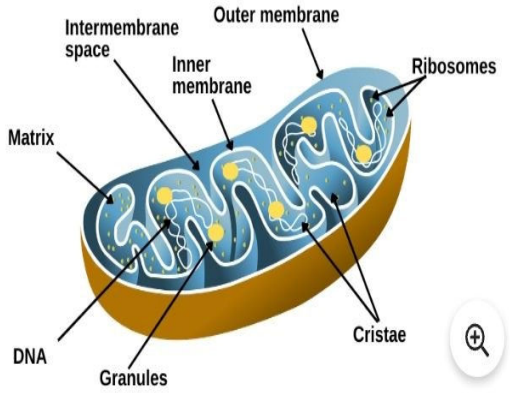
Cellular respiration

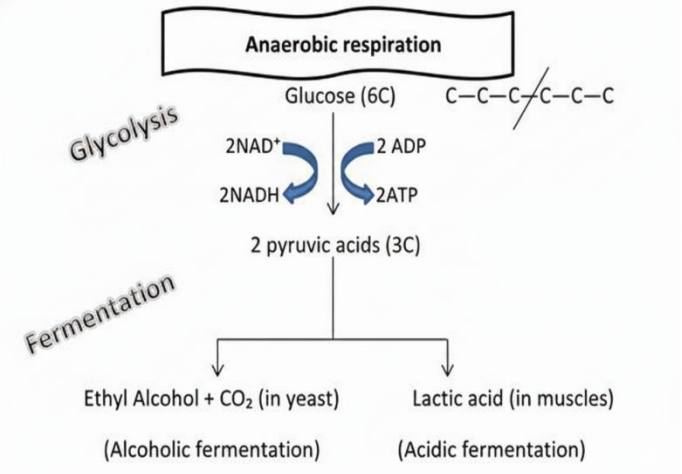


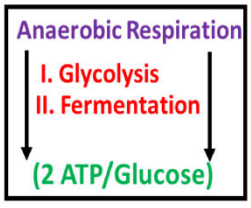


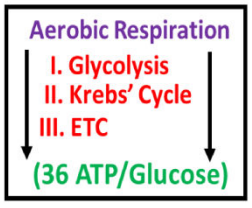
Aerobic respiration | Anaerobic respiration

A COMPARATIVE GUIDE: CELLULAR RESPIRATION

Aerobic respiration	Anaerobic respiration
1) In presence of Oxygen	1) In absence of Oxygen
2) 3 steps: glycolysis (cytoplasm), krebs cycle (matrix) and ETC (cristae)	2) 2 steps: glycolysis and fermentation
3) Occurs in cytosol (cytoplasm) and mitochondria	3) Occurs in cytoplasm only
4) More energy (38 or 36 ATP)	4) Less energy (2 ATP)
5) CO_2 and water are the by-products	5) CO_2 and alcohol or lactic acids are the by-products
6) Occurs in higher org	6) Occurs in primitive organisms like yeast

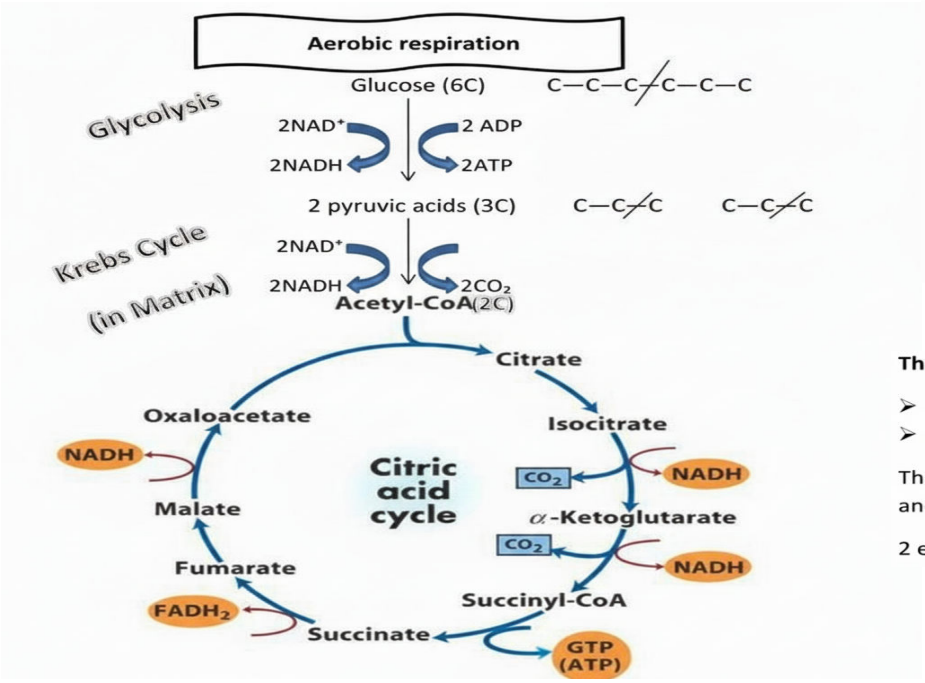






- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
- **Glycolysis** (glucose → pyruvic acid, 2 ATP & 2 NADH)
- Fermentation (pyruvic → lactic acid in muscles or alcohol in yeast)
- Lactic acid in muscles causes fatigue sensation due to insufficient oxygen supply
- 1 NADH = 3 ATP , 1 $FADH_2$ = 2 ATP

- During photosynthesis, reduction occurs (gaining of electrons) while during respiration, oxidation occurs (losing of electrons)
- The net yield of **krebs cycle**: 4 ATP molecules, 2 $FADH_2$ molecules, 10 NADH molecules & 6 CO_2 molecules are produced



The net yield:

- 4 ATP molecules
- 2 $FADH_2$ molecules
- 10 NADH molecules
- 6 CO_2 molecules

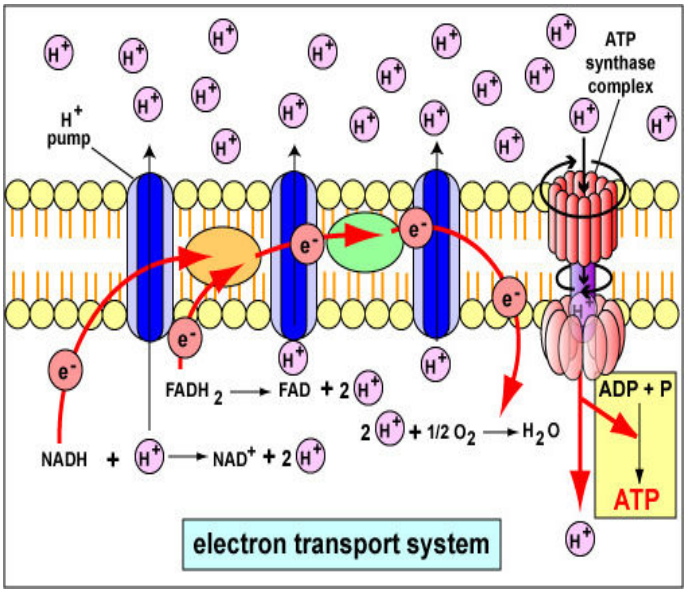
The net yield for 1 glucose moleule:

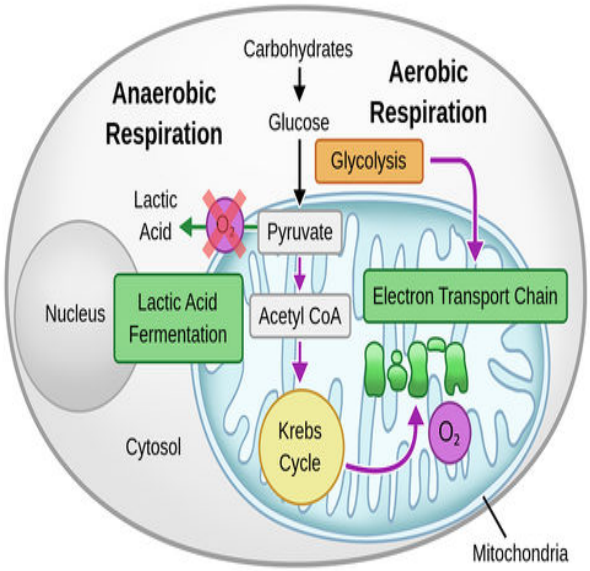
- 38 ATP in prokaryotes
- 36 ATP in eukaryotes

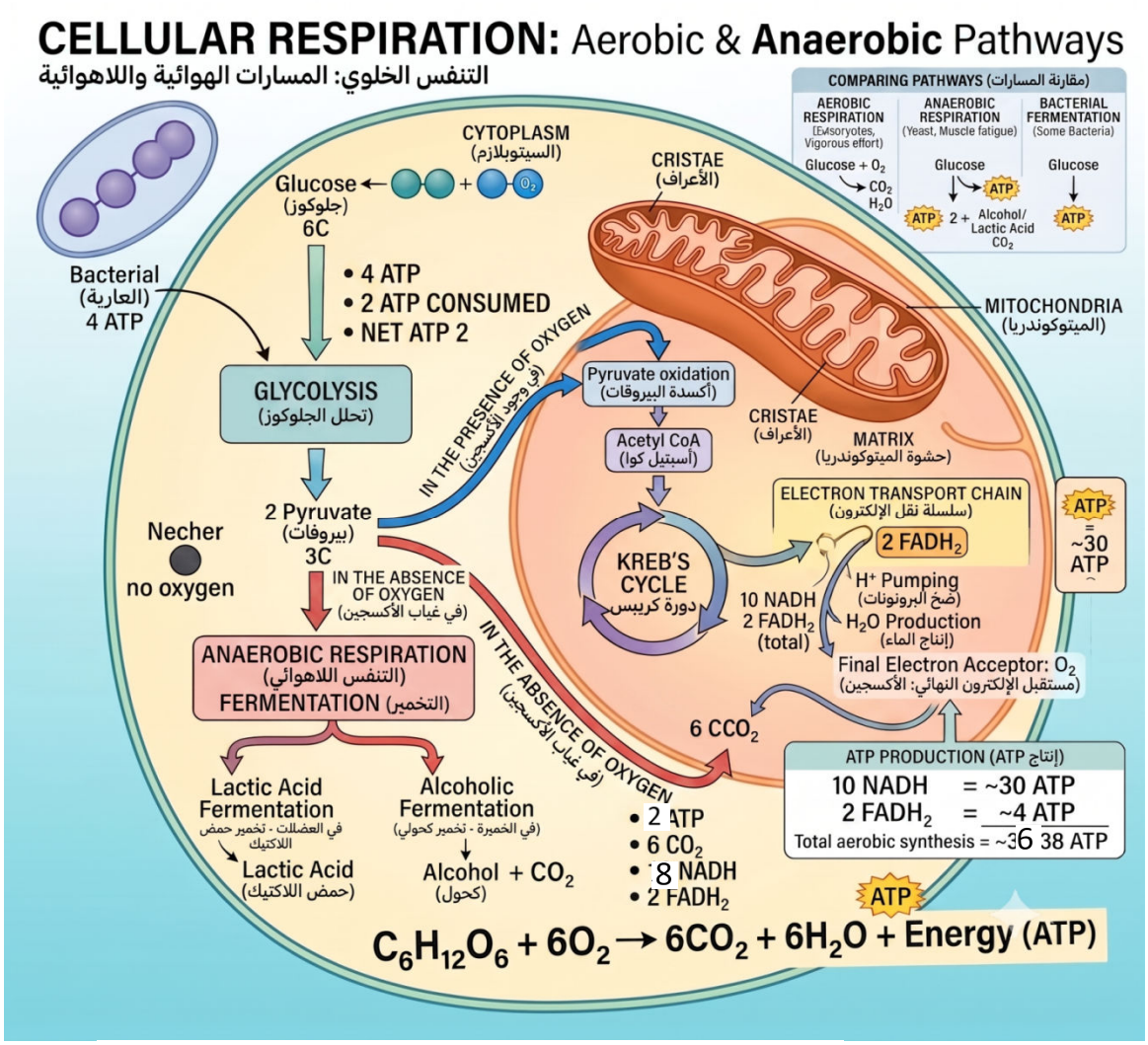
The oxygen serves as the final electron and proton acceptor in ETC

$2\ e^- + 2H^+ + ½\ H^+ + ½\ O_2 \longrightarrow H_2O$

- **Electron transport chain = Chemiosmosis = Oxidative phosphorylation**: using the stored energy to convert ADP into ATP by the aid of enzyme ATP synthetase
- ETC → Occurs in Cristae, oxygen serves as substrate, most of ATP, H_2O is produced, ATP synthetase enzyme & protons are pumped
- During cell respiration, electrons of NADH & $FADH_2$ are pulled along the ETC, they released energy used to pump protons (H^+) across the cristae membrane, thus creating a proton gradient
- The immediate result of ETC is that a proton gradient is created
- Mitochondria & chloroplast → both contain DNA, use ETC & both form ATP

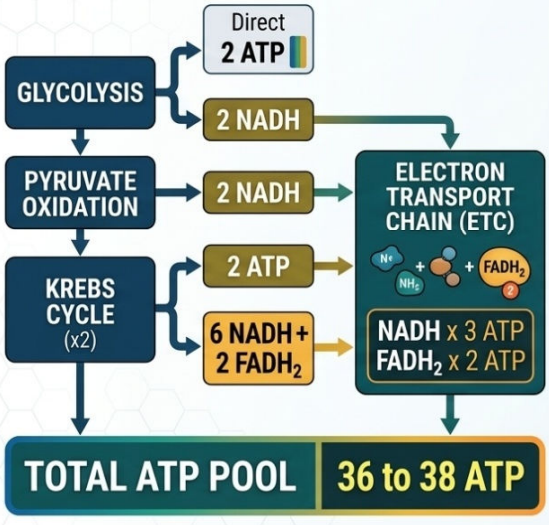





CELLULAR RESPIRATION: Aerobic & Anaerobic Pathways
التنفس الخلوي: المسارات الهوائية واللاهوائية
COMPARING PATHWAYS (مقارنة المسارات)
AEROBIC RESPIRATION (Eukaryotes, Vigorous effort)
ANAEROBIC RESPIRATION (Yeast, Muscle fatigue)
BACTERIAL FERMENTATION (Some Bacteria)
Glucose + O2 → CO2 H2O
Glucose → ATP → 2 ATP + Alcohol/ Lactic Acid CO2
Glucose → ATP
CYTOPLASM (السيتوبلازم)
Glucose (جلوكوز) 6C
Bacterial (العارية) 4 ATP
• 4 ATP
• 2 ATP CONSUMED
• NET ATP 2
GLYCOLYSIS (تحلل الجلوكوز)
2 Pyruvate (بيروفات) 3C
IN THE PRESENCE OF OXYGEN (في وجود الأكسجين)
CRISTAE (الأعراف)
MITOCHONDRIA (الميتوكوندريا)
Pyruvate oxidation (أكسدة البيروفات)
Acetyl CoA (أسيتيل كوا)
CRISTAE (الأعراف)
MATRIX (حشوة الميتوكوندريا)
KREB'S CYCLE دورة كريبس
ELECTRON TRANSPORT CHAIN (سلسلة نقل الإلكترون)
2 FADH2
H+ Pumping (ضخ البروتونات)
H2O Production (إنتاج الماء)
10 NADH 2 FADH2 (total)
Final Electron Acceptor: O2 (مستقبل الإلكترون النهائي: الأكسجين)
ATP = ~30 ATP
Necher no oxygen
IN THE ABSENCE OF OXYGEN (في غياب الأكسجين)
ANAEROBIC RESPIRATION (التنفس اللاهوائي)
FERMENTATION (التخمير)
IN THE ABSENCE OF OXYGEN (في غياب الأكسجين)
6 CCO2
Lactic Acid Fermentation في العضلات - تخمير حمض اللاكتيك
Lactic Acid (حمض اللاكتيك)
Alcoholic Fermentation (في الخميرة - تخمير كحولي)
Alcohol + CO2 (كحول)
• 2 ATP
• 6 CO2
• 8 NADH
• 2 FADH2
ATP PRODUCTION (ATP إنتاج)
10 NADH = ~30 ATP
2 FADH2 = ~4 ATP
Total aerobic synthesis = ~36 38 ATP
ATP
C6H12O6 + 6O2 → 6CO2 + 6H2O + Energy (ATP)

1ATP = 45 KJ

FULL ATP YIELD IN AEROBIC CELLULAR RESPIRATION (per Glucose Molecule)



RESPIRATION PHASE	DIRECT ATP YIELD (Substrate-Level Phos.)	ELECTRON CARRIER YIELD (NADH & FADH2)	ATP FROM ELECTRON TRANSPORT CHAIN (ETC)	PHASE TOTAL ATP
GLYCOLYSIS	2 ATP	2 NADH	4 or 6 ATP*	Total: 6 or 8 ATP
PYRUVATE OXIDATION (x2)	0 ATP	2 NADH (Total)	6 ATP	Total: 6 ATP
KREBS CYCLE (x2)	2 ATP	6 NADH + 2 FADH2 (Total)	18 ATP + 4 ATP = 22 ATP	Total: 24 ATP
TOTAL YIELD	4 ATP	10 NADH + 2 FADH2	32 to 34 ATP	GRAND TOTAL: 36 to 38 ATP

*ETC ATP yield from Glycolysis depends on the Shuttle System used (Malate-Aspartate = 6 ATP; Glycerol-Phosphate = 4 ATP).